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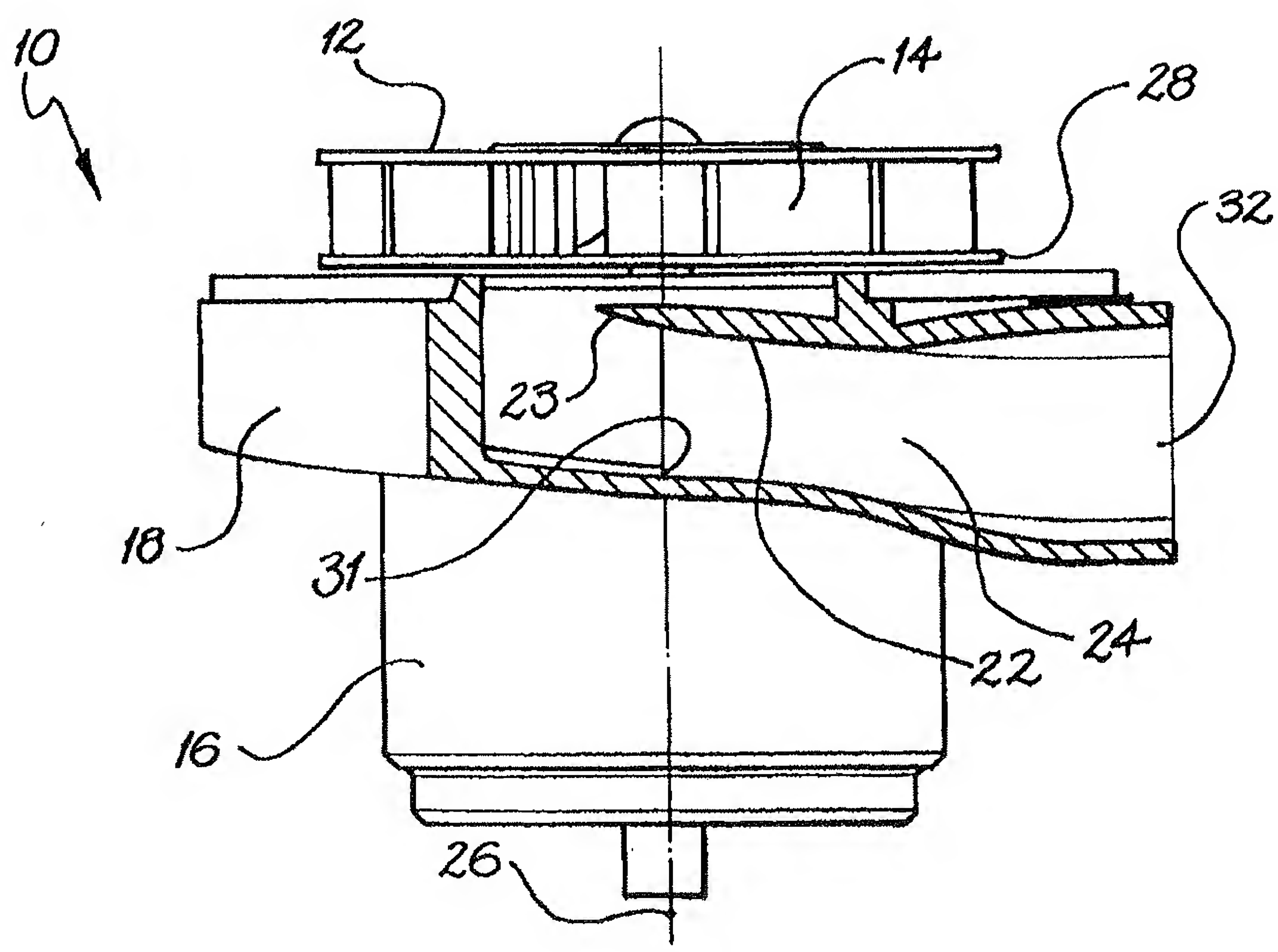
(54) Title: A HOUSING FOR A CENTRIFUGAL IMPELLER



(57) Abstract

A housing (10) for a centrifugal impeller (12). The housing (10) has a flow dividing tongue (22) at least partially defining an outlet (24) from the housing (10). The tongue (22) is axially displaced from the impeller (12).

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A HOUSING FOR A CENTRIFUGAL IMPELLER

FIELD OF THE INVENTION

The present invention relates to a housing for a centrifugal impeller.

The housing has been primarily developed for use in an apparatus for supplying breathable gas, as is used in the generation of the pressurised gas required for Continuous Positive Airway Pressure (CPAP) treatment of sleep disordered breathing conditions such as Obstructive Sleep Apnea (OSA) syndrome and other ventilatory assistance treatments such as Non Invasive Position Pressure Ventilation (NIPPV). The invention will be described hereinafter with reference to this application, however, it will be appreciated that the invention also finds application in many other fields where a centrifugal impeller or fan is used to drive a fluid.

BACKGROUND OF THE INVENTION

CPAP treatment is a common ameliorative treatment for breathing disorders including OSA. CPAP treatment, as described in US Patent No. 4,944,310, provides pressurised air or other breathable gas to the entrance of a patient's airways at a pressure elevated above atmospheric pressure, typically in the range 4-20 cm H_2O.

It is also known for the level of treatment pressure to vary from breath to breath in accordance with patient need, that form of CPAP being known as automatically adjusting nasal CPAP treatment, as described in US Patent No. 5,245,995.

NIPPV is another form of treatment for breathing disorders which can involve a relatively higher pressure of gas being provided in the patient mask during the inspiratory phase of respiration and a relatively lower pressure or atmospheric pressure being provided in the patient mask during the expiratory phase of respiration.

In other NIPPV modes the pressure can be made to vary in a complex manner throughout the respiratory cycle. For example, the pressure at the mask during inspiration or expiration can be varied through the period of treatment.

Typically, the ventilatory assistance for CPAP or NIPPV treatment is delivered to the patient by way of a nasal mask. Alternatively, a mouth mask or full face mask or nasal prongs can be used. In this specification any reference to a mask is to be understood as incorporating a reference to a nasal mask, mouth mask, full face mask or nasal prongs.

In this specification any reference to CPAP treatment is to be understood as embracing all of the above described forms of ventilatory treatment or assistance.

An apparatus for supplying breathable gas broadly comprises a flow generator constituted by a continuous source of air or other breathable gas generally in the form of a blower or turbine having a centrifugal impeller driven by an electric motor. The gas supply is connected to a conduit or tube, which in turn is connected to a patient mask which incorporates, or has in close proximity, an exhaust to atmosphere for venting exhaled gases. The electric motor is typically controlled by a servo-controller under the control of a micro controller unit.

The above described forms treatment are usually carried out whilst the patient is sleeping. It is thus desirable to minimise the noise produced by the breathable gas supply apparatus, which is generally located within 1 to 2 metres of the patient.

A common housing for a centrifugal impeller is termed a radial volute which comprises a housing around the impeller having a flow dividing tongue parallel to the rotational axis of the impeller. Starting at the tongue, the housing spirals away from, and around, the impeller to form a duct of increasing area in the plane of the impeller. The tongue splits the flow and thus partially defines the outlet of the housing. Although radial volutes are efficient in terms of the pressure produced relative to flow rate and fan speed, they are extremely noisy as pressure pulses from the blades of the impeller can pass directly into the outlet and create a high frequency scream known as a blade passing tone.

A Rotron (Trade Mark) blower produced by EG & G ROTRON, Woodstock, New York, USA, as used in the present applicant's VPAP II (Trade Mark) flow generator, is an example of a radial volute fan housing.

An alternative design termed a plenum fan housing directs the gas through a slim annular zone between the impeller outlet (ie. the impeller exterior) and the adjacent housing interior and thereafter into a toroidal plenum chamber having a tangential outlet passage. As the plenum chamber and the outlet passage are offset from the impeller outlet, there is no direct path from the impeller outlet to the outlet passage and the plenum fan housing is effective in suppressing the blade passing tone mentioned above.

However, forcing the gas through the slim annular zone is very inefficient and creates a pressure drop. As an example, at a comparable flow rate a plenum fan housing would produce approximately 20% less pressure than a similar sized motor and impeller using a radial volute fan housing.

The plenum fan configuration is used in the present applicant's SULLIVAN V and AUTOSET T CPAP machines, Respironic Inc.'s SOLO CPAP machine and Healthdyne Inc.'s QUEST CPAP machine (SULLIVAN V, AUTOSET T, SOLO and QUEST are Trade Marks of their respective companies).

It is an object of the present invention to provide a housing for a centrifugal impeller with increased efficiency compared to the prior art plenum fan housing whilst suppressing the blade passing tone.

SUMMARY OF THE INVENTION

Accordingly, in a first aspect, the present invention provides a housing for a centrifugal impeller having a flow dividing tongue at least partially defining an outlet from the housing, wherein the tongue is axially displaced from the impeller.

In one embodiment, the tongue has a leading edge extending substantially radially from the rotational axis of the impeller.

In another embodiment, the tongue has a leading edge extending substantially tangentially from the outer periphery of the impeller.

Preferably, the tongue comprises a first end of a substantially spiral shaped wall that extends to a second end further axially displaced from the impeller.

The housing preferably also includes an inlet portion having a central gas inlet disposed adjacent the inlet of the impeller.

In one form, the outlet is preferably a passage of substantially rectangular cross section having one side defined by the tongue. In other forms, the outlet passage is substantially semi-circular or D-shaped in cross section or the like. The outlet passage desirably blends into a slightly frustoconical form diverging away from the flow dividing tongue.

The tongue preferably constitutes the upper side of the outlet. The tongue is preferably axially displaced below the lower edge of the impeller.

The housing is preferably comprised of a first sub-housing including the wall and the outlet passage and a second sub-housing including the gas inlet.

The first and second sub-housing are preferably joined together after the impeller is installed therebetween.

The first sub-housing is desirably fastened to an electric motor and includes an opening to allow a drive shaft of the motor to pass through the first sub-housing and engage the impeller.

BRIEF DESCRIPTION OF THE DRAWINGS

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a side view of a flow generator having a housing according to a first embodiment of the invention with the second sub-housing shown in phantom;

Fig. 2 is a perspective view of the flow generator shown in Fig. 1 with the second sub-housing removed;

Fig. 3 is a plan view of the flow generator shown in Fig. 2;

Fig. 4 is a sectional side view of the flow generator of Fig. 2 along line 4-4 of Fig. 3;

Fig. 5 is a plan view of the flow generator of Fig. 1 including the second sub-housing;

Fig. 6 is a sectional side view of the flow generator of Fig. 1 along line 6-6 of Fig. 5;

Fig. 7 is a graph showing the noise level produced by flow generators over range of gas supply pressures;

Fig. 8 is a graph showing the power consumed by flow generators over a range of gas flow rates;

Fig. 9 is a plan view of a first sub-housing according to a second embodiment of the invention;

Fig. 10 is a sectional side view of the first sub-housing shown in Fig. 9 along line 10-10;

Fig. 11 is a top plan view of a first sub-housing according to a third embodiment of the invention; and

Fig. 12 is a top isometric view of the first sub-housing shown in Fig. 11.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, there is shown an embodiment according to the present invention of a housing 10 for a centrifugal impeller 12. The impeller 12 has a central gas inlet 13, blades 14 and is mounted on a drive shaft 15 (see Fig. 6) of an electric motor 16. The housing 10 is comprised of a first sub-housing 18 and a second sub-housing 20 which is shown in phantom in Fig. 1.

As best seen in Figs. 3 and 4, the first sub-housing 18 includes a flow dividing tongue 22 having a leading edge 23 which at least partially defines an outlet 24 from the housing 10. In the embodiment shown, the outlet 24 is a passage of rectangular

cross-section and the tongue 22 defines the upper side or roof of the outlet passage 24. The leading edge 23 of the tongue 22 is oriented radially from the rotational axis 26 of the impeller and, as best shown in Fig. 6, is axially displaced from the impeller 12 along the axis 26. In relation to the orientation of the housing 10 shown in Fig. 6, the impeller 12 has a bottom edge 28 and the tongue 22 is axially displaced below the bottom edge 28.

The tongue 22 is at the end of a substantially spiral shaped floor or wall 30 which extends through approximately 360° from a first end having the tongue 22, which is displaced slightly below the bottom edge 28 of the impeller 12, to a second end 31 displaced further from the bottom edge 28 and below the first end or tongue 22. The end 31 of the wall 30 defines the floor of the rectangular outlet passage 24. The outlet passage 24 blends from the rectangular cross-section into a slightly frustoconical outlet duct 32 diverging away from the flow dividing tongue 22. As best seen in Fig. 4, the leading edge 23 of the tongue 22 is tapered or sharpened to minimise disturbance of the gas entering the outlet 24.

The second sub-housing 20 includes a central gas inlet 34 which is disposed adjacent the inlet 13 of the impeller 12.

The first sub-housing 18 is fastened to the motor 16 and includes an opening 38 (see Fig. 6) to allow the motor drive shaft 15 to pass through the first sub-housing 18 and engage an inner hub 39 of the impeller 12. After the first sub-housing 18 is fastened to the motor 16 and the impeller 12 is mounted on the drive shaft 15, the second sub-housing 20 is glued or ultrasonically welded to the first sub-housing 18 at matching shoulders 41 to form the housing 10.

The gas outlet of the impeller 12 is defined by the outermost edges 40 of the blades 13. The blade edges 40 are adjacent a substantially annular zone 42 between the edges 40 and an external side wall 44 of the second sub-housing 20. A tapered spiralling substantially annular zone 46 is defined between internal and external walls 48 and 50 of the first sub-housing 18 and the spiral floor 30.

In use, energising the motor 16 rotates the impeller 12 and draws gas through the impeller inlet 13 and forces it centrifugally out of the impeller 12 from the blade edges 40. The pressurised gas is initially forced into the zone 42. The gas is also forced into the zone 46 above the spiral wall 30 which causes it to be gradually slowed in the zones 42 and 46, thereby minimising pressure losses, until an outlet stream of gas is separated by the offset flow dividing tongue 22 and exits the housing 10 through the outlet duct 32 via the outlet passage 24.

The housing 10 suppresses the blade passing tone as there is no direct path for pressure pulses leaving the blades edges 40 of the impeller 12 directly into the outlet passage 24. Further, the gradual slowing of the gas and the lack of any slim annular zone through which the gas is forced results in lower pressure losses and thus higher pressure generation than the prior art plenum fan design.

Figs. 7 and 8 are plots of characteristics of the housing 10 of the preferred embodiment compared to a radial volute housing and a plenum fan housing of comparable size. In both plots the housing 10 is represented by line 52, the radial volute housing by line 54 and the plenum fan housing by line 56.

Fig. 7 is a plot of sound pressure (dBA) levels emitted by the housings over a range of gas outlet pressures (cm H_2O) discharging through a fixed orifice and shows that the housing 10 produces noise comparable to the plenum fan housing and lower, and thus superior, to the radial volute. Further, the housing 10 does not exhibit the noise level spike between 13 and 17 cm H_2O created by the blade passing tone in the radial valute housing.

Fig. 8 is a plot of power usage (W) of the housings over a range of gas flow rates (ℓ /min) and shows that the housing 10 uses power comparable to the radial volute housing and lower, and thus superior, to the plenum fan housing.

Figs. 9 and 10 show a second embodiment of the first sub-housing 18 having a semi-circular wall 30 that, in combination with the tongue 22, defines a substantially D-shaped outlet passage 24 and annular zone 46.

In this embodiment, the cross section of the floor or wall 30 gradually curves from being straight at its first end, which comprises the tongue 22, to semi-circular at its second end 31 as it extends through its 360° path around the impeller 12.

Figs. 11 and 12 show a third embodiment of a first sub-housing 18 in which the leading edge 23 of the flow dividing tongue 22 is oriented substantially tangentially from the periphery of the impeller 12. In this embodiment the upper side or roof of the outlet 24 is formed in the wall 58 of the first sub-housing 18.

The housings according to the preferred embodiments of the invention are advantageous because they produce less noise than the radial volute housing whilst having a power usage comparable to the radial volute housing but lower, and thus superior, power usage (i.e. efficiency) to the plenum fan housing.

Although the invention has been described with reference to a specific example, it would be appreciated by those skilled in the that the invention may be embodied in many other forms.

CLAIMS:

1. A housing for a centrifugal impeller having a flow dividing tongue at least partially defining an outlet from the housing, wherein the tongue is axially displaced from the impeller.

2. The housing as claimed in claim 1, wherein the impeller has a rotational axis and the tongue has a leading edge extending substantially radially from the impeller rotational axis.

3. The housing as claimed in claim 1, wherein the impeller has an outer periphery and the tongue has a leading edge extending substantially tangentially from the impeller outer periphery.

4. The housing as claimed in claim 1, 2 or 3, wherein the tongue comprises a first end of a substantially spiral shaped wall that extends to a second end further axially displaced from the impeller.

5. The housing as claimed in claim 4, wherein the impeller includes an inlet and housing includes an inlet portion having a central gas inlet disposed adjacent the impeller inlet.

6. The housing as claimed in claim 5, wherein the housing is comprised of a first sub-housing including the wall and the outlet passage and a second sub-housing including the gas inlet.

7. The housing as claimed in claim 6, wherein the first and second sub-housing are joined together after the impeller is installed therebetween.

8. The housing as claimed in claim 6 or 7, wherein the first sub-housing is fastened to an electric motor and includes an opening to allow a drive shaft of the motor to pass through the first sub-housing and engage the impeller.

9. The housing as claimed in any one of the preceding claims, wherein the outlet includes a passage of substantially rectangular cross section having one side defined by the tongue.

10. The housing as claimed in any one of claims 1 to 8, wherein the outlet includes a passage of substantially semi-circular or D-shaped cross section having one side defined by the tongue.

11. The housing as claimed in claim 10 or 11, wherein the outlet passage blends into a slightly frustoconical form diverging away from the tongue.

12. The housing as claimed in claim 9, 10 or 11, wherein the tongue constitutes the upper side of the outlet passage.

13. The housing as claimed in any one of the preceding claims, wherein the impeller includes a lower edge and the tongue is axially displaced below the impeller lower edge.

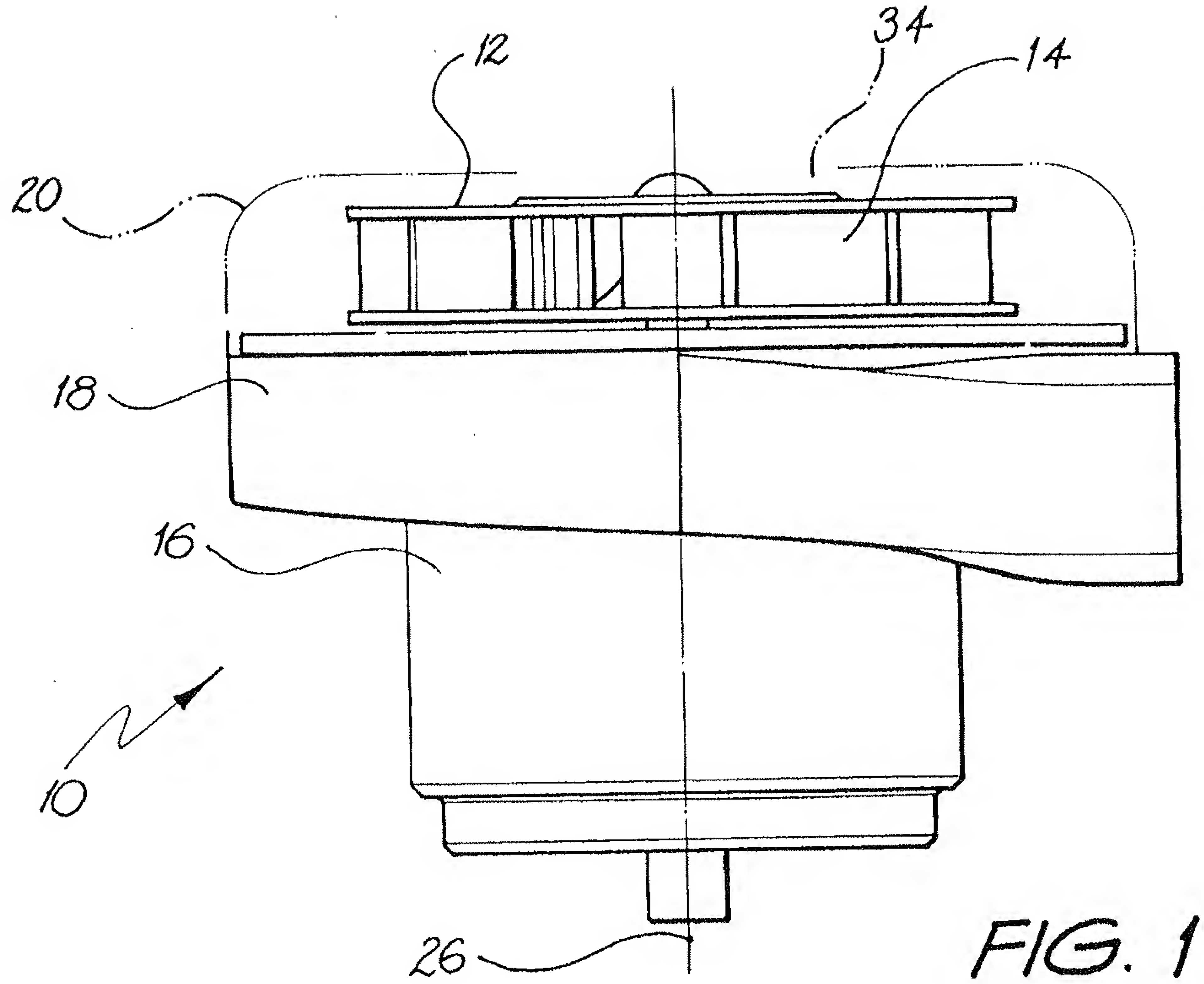


FIG. 1

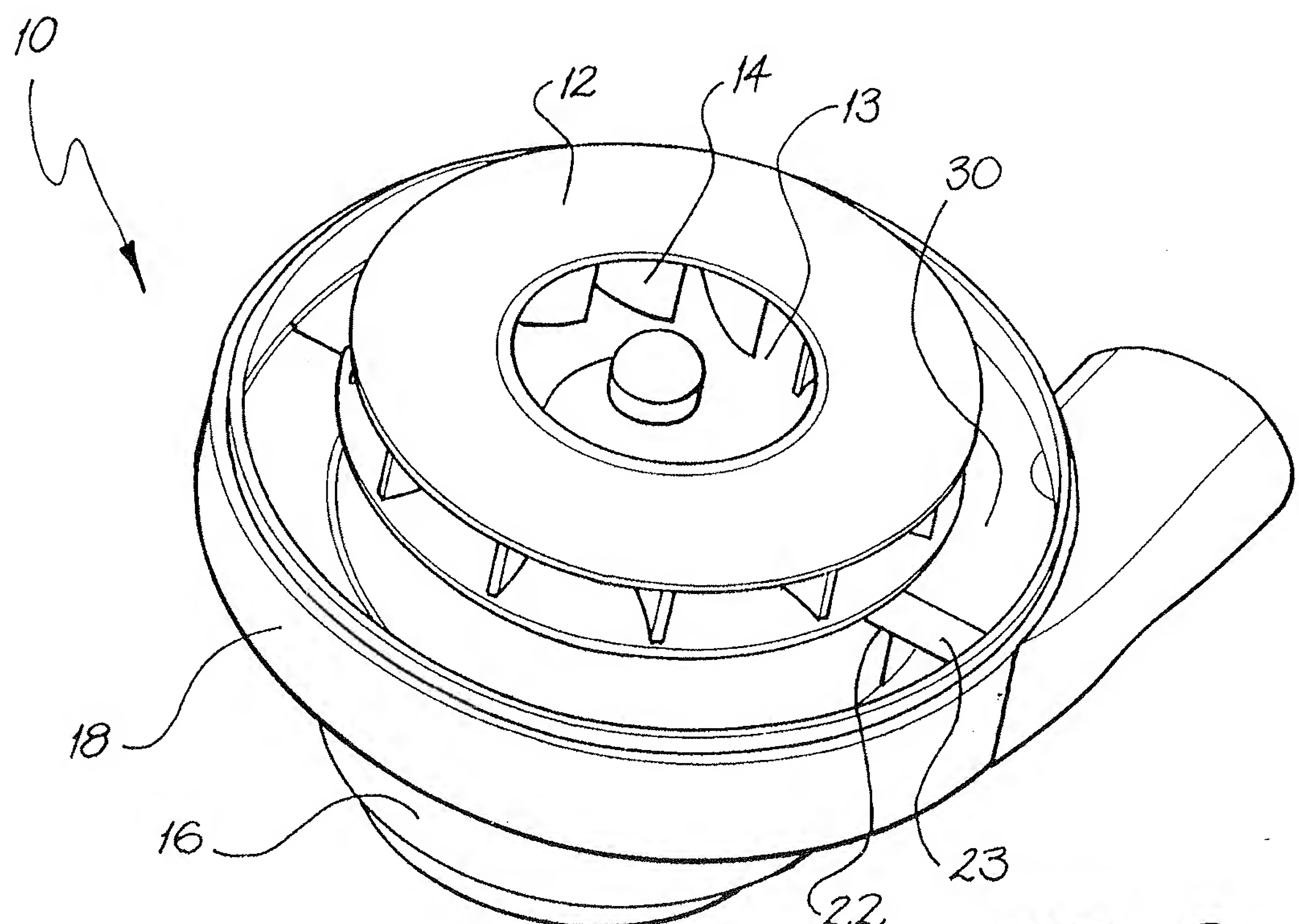


FIG. 2

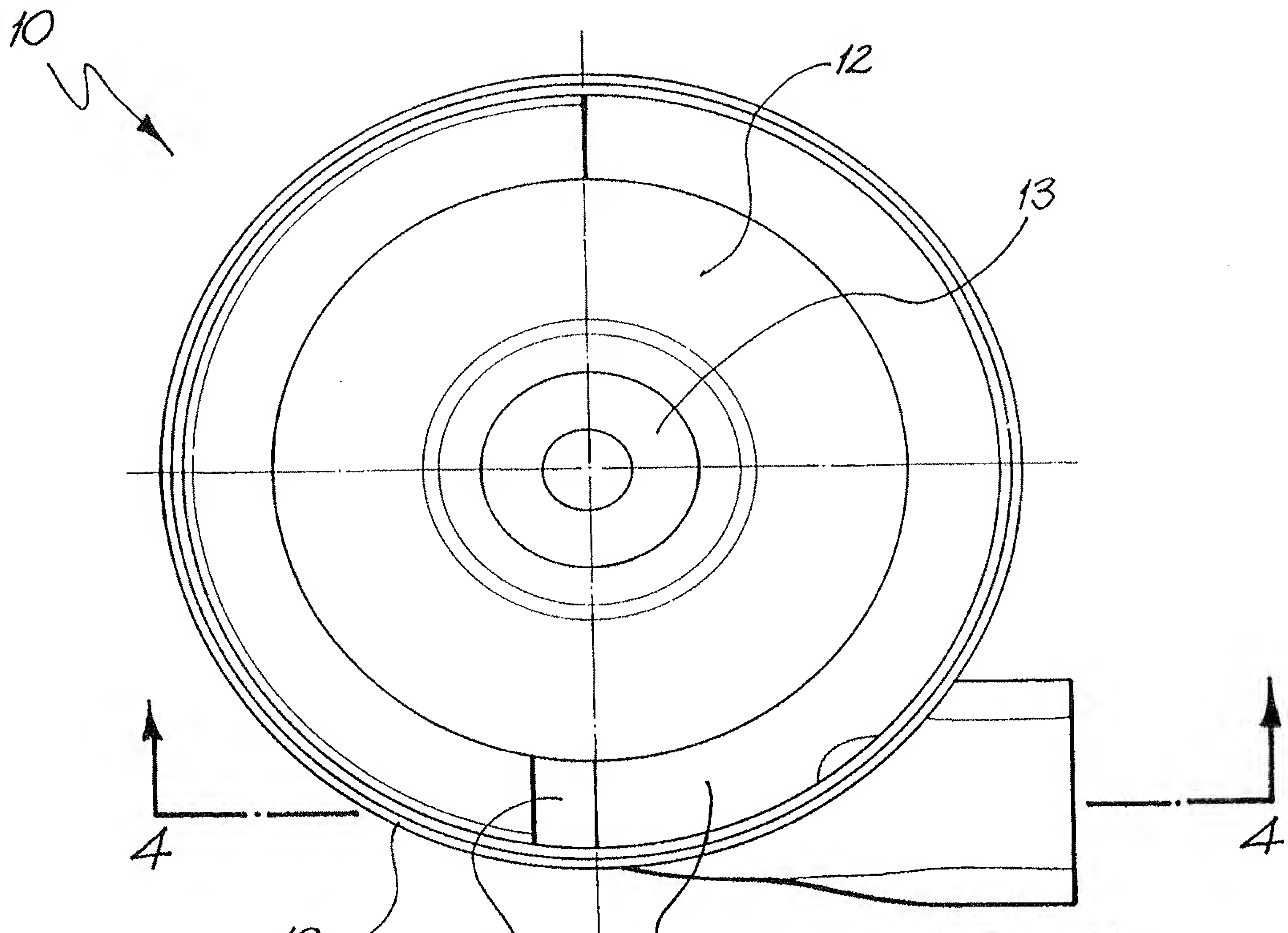


FIG. 3

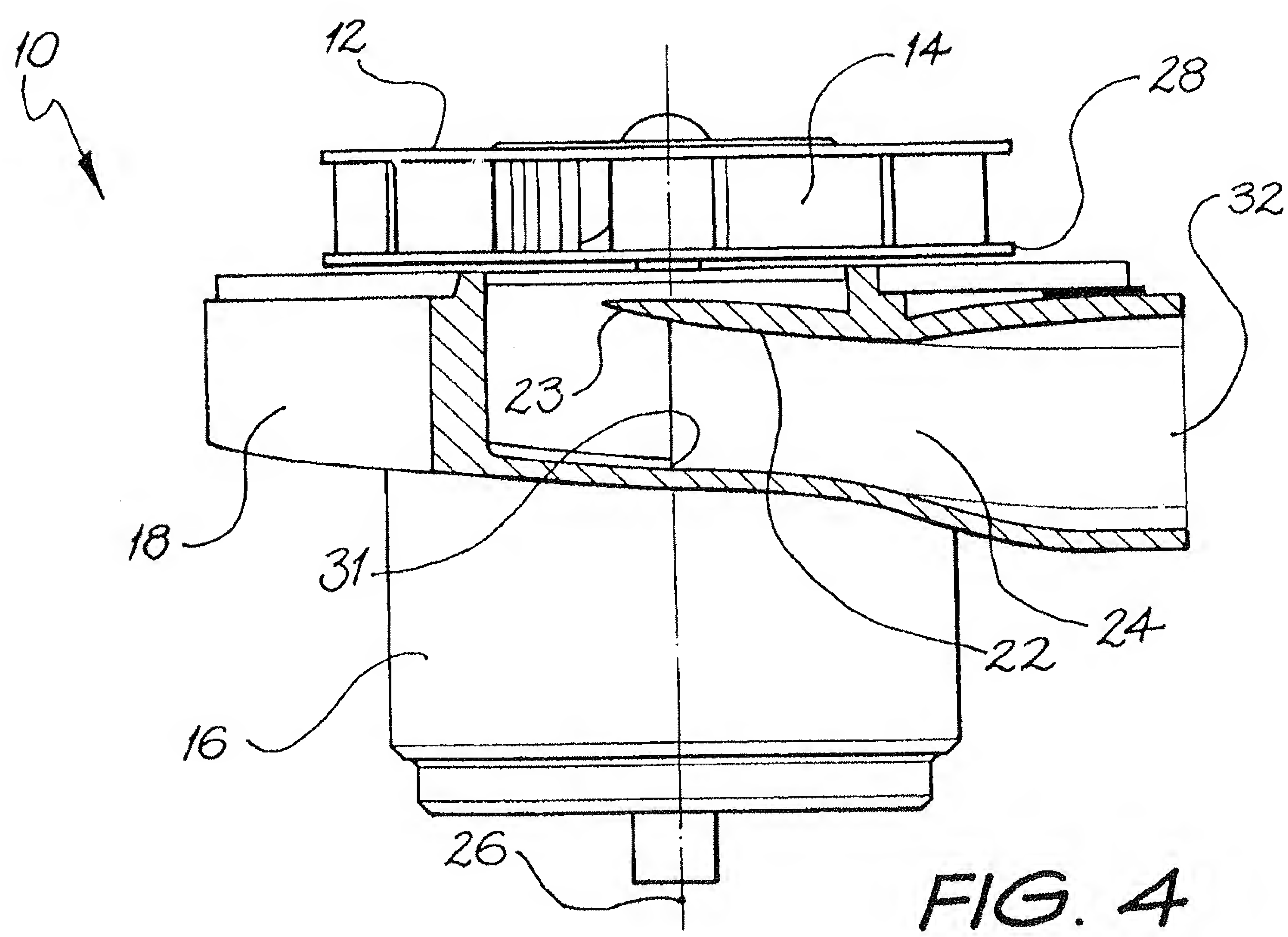


FIG. 4

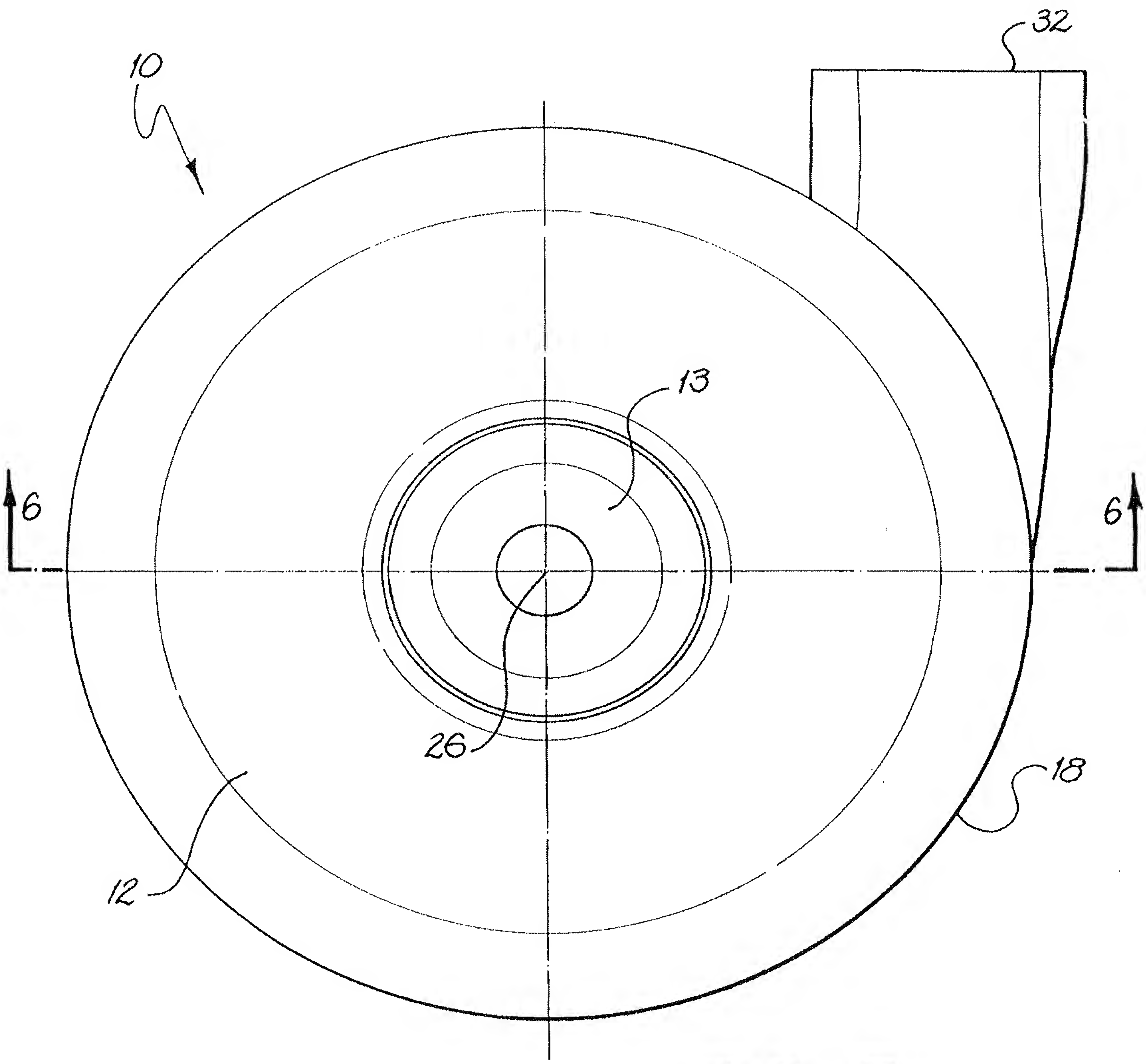


FIG. 5

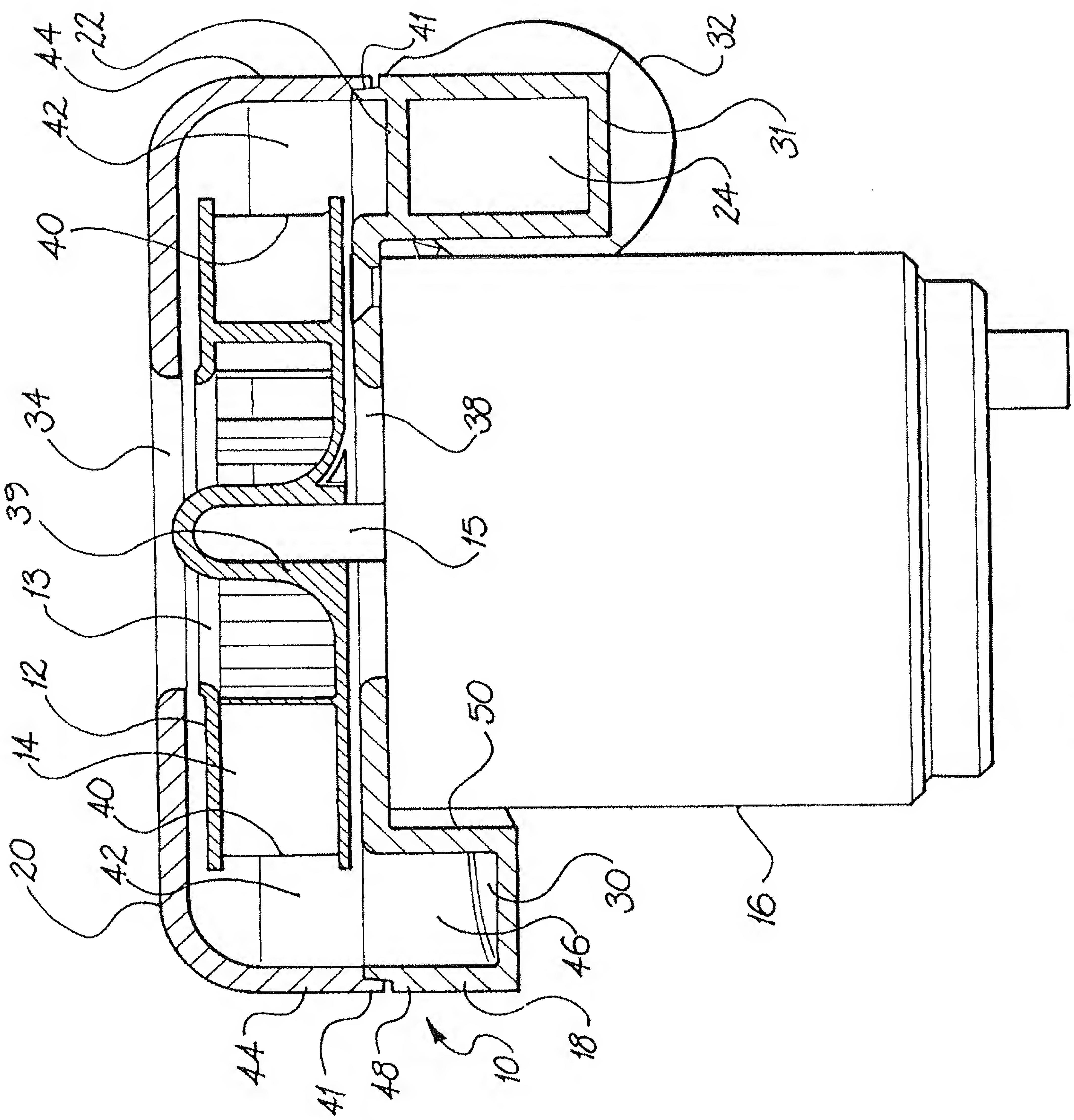


FIG. 6

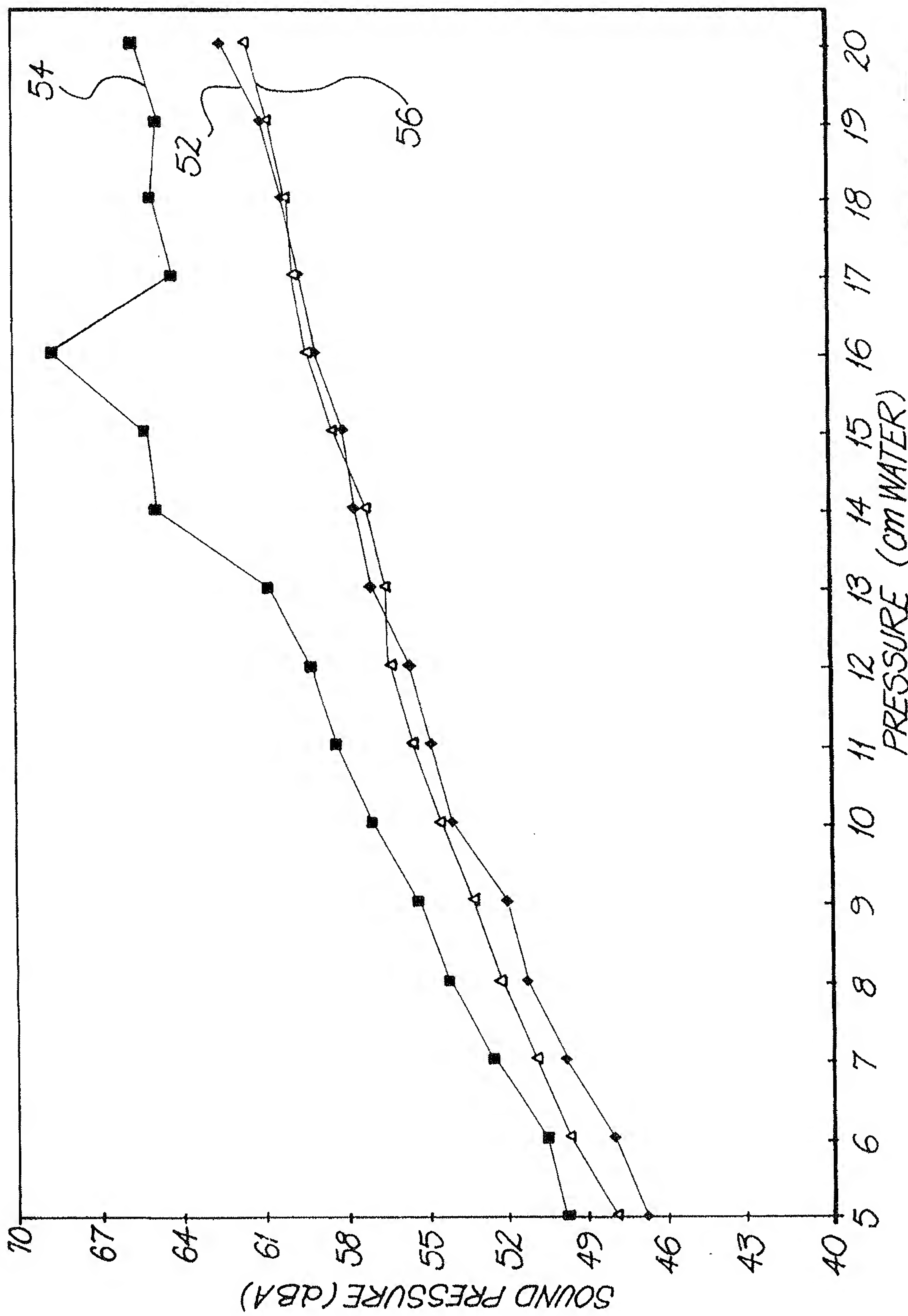
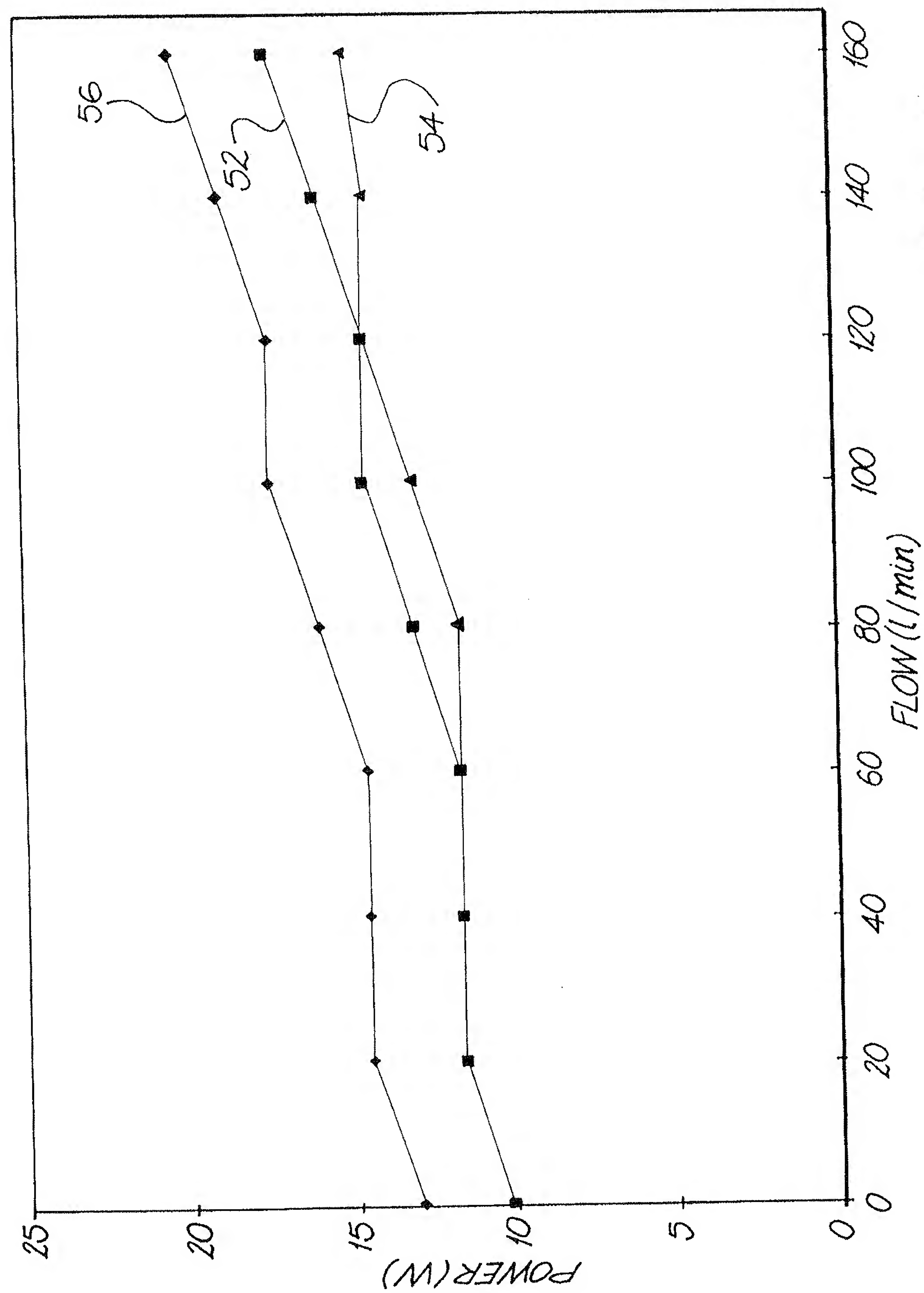

54
52
56
70
67
64
61
58
55
52
49
46
43
40
SOUND PRESSURE (dBA)
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
PRESSURE (cm WATER)

FIG. 7


56
52
54
POWER (W)
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10
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20
25
FLOW (l/min)
0
20
40
60
80
100
120
140
160

FIG. 8

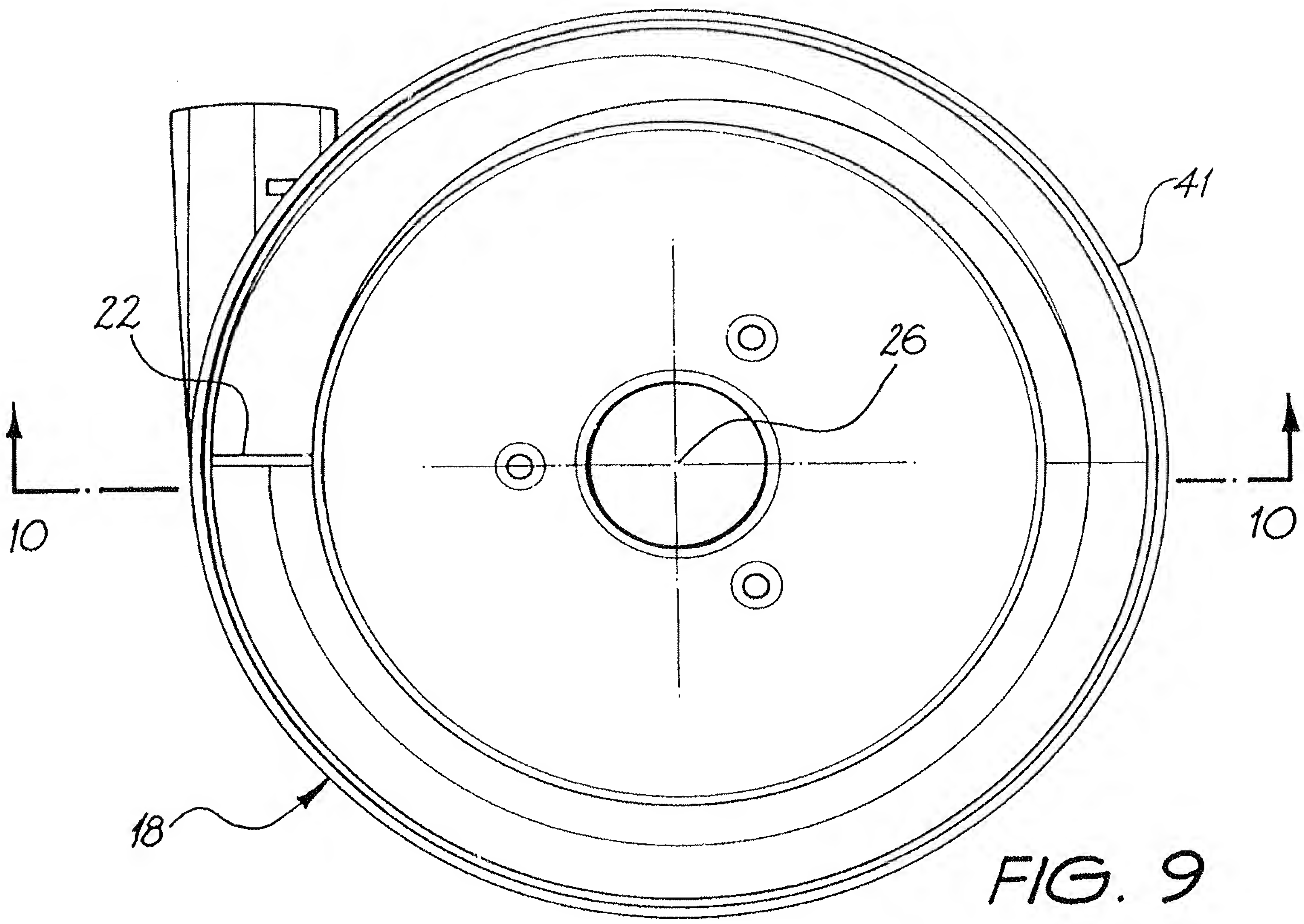

FIG. 9

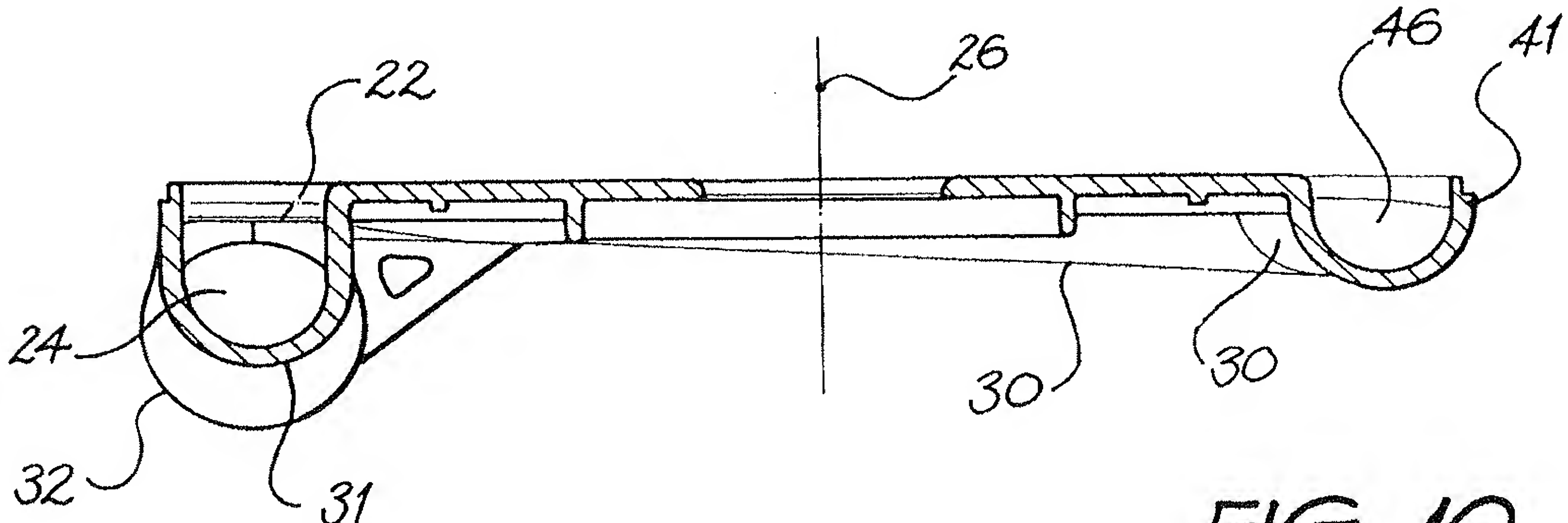

FIG. 10

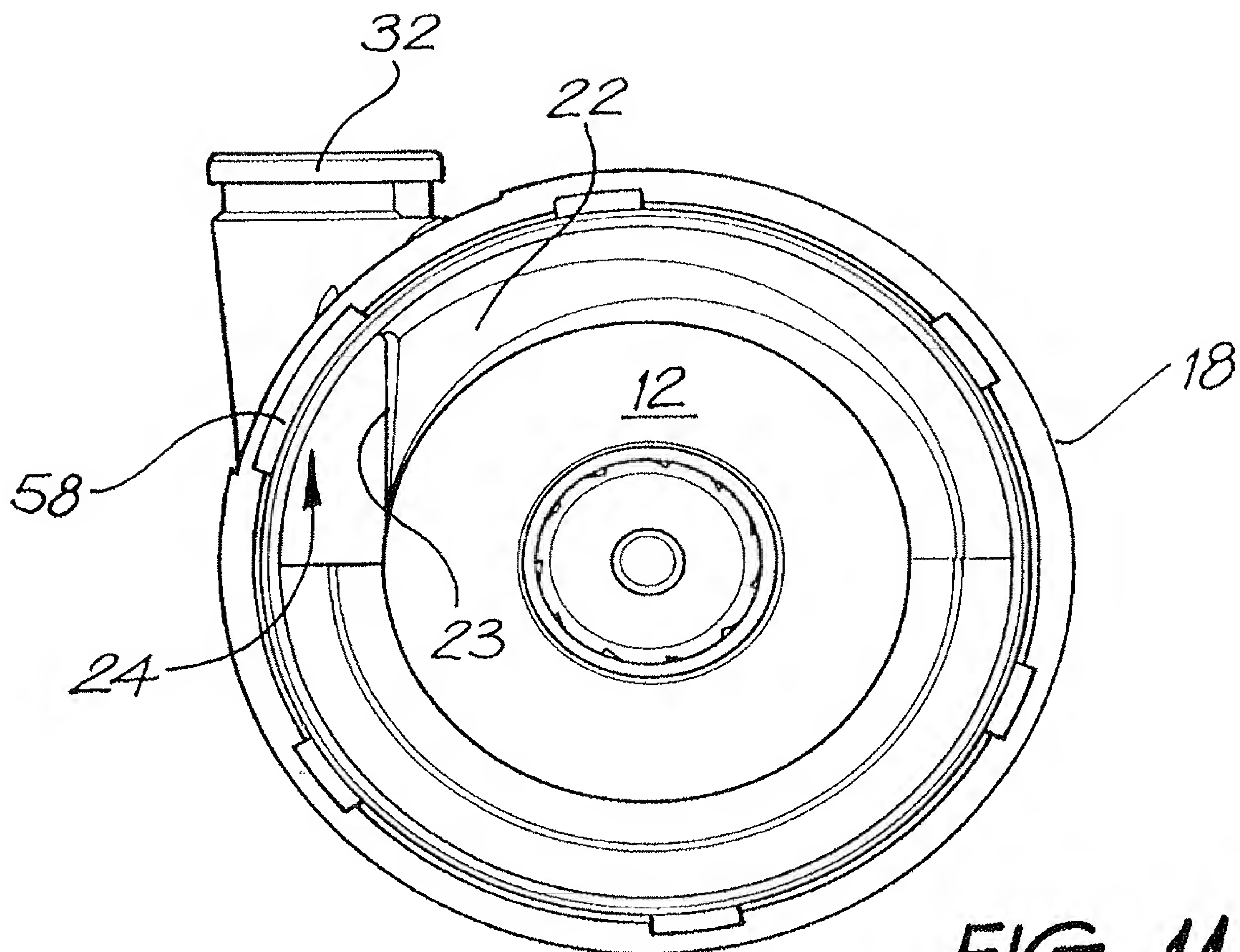

FIG. 11

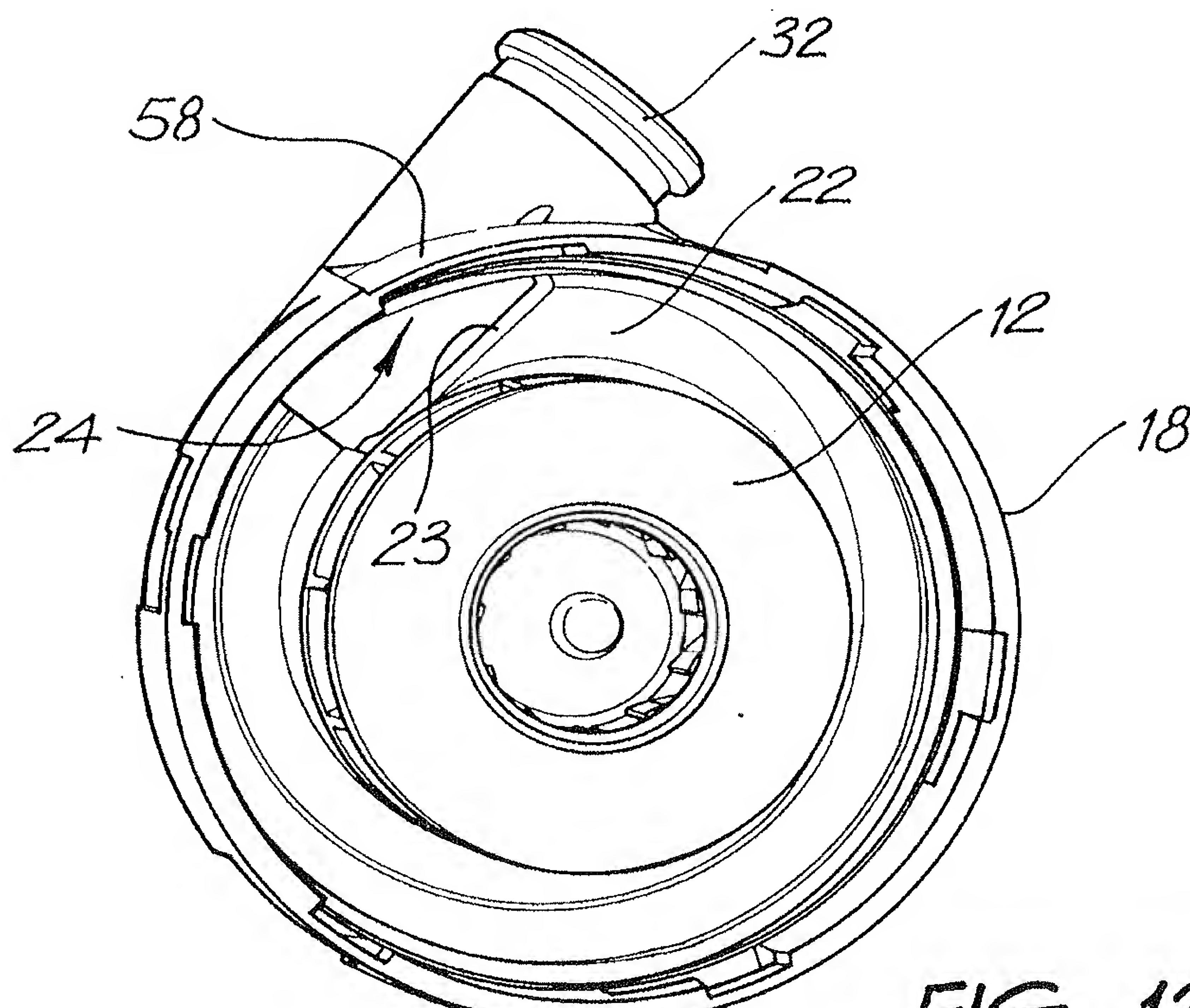

FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU 99/00444

A.	CLASSIFICATION OF SUBJECT MATTER
Int Cl6:	F04D 29/42, 29/44; A61M 16/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPAT with keywords

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	AU 28503/30 A (GEO.W.KELLY& LEWIS PROPRIETARY LIMITED) 18 August 1931 Column 4, line 51- column 9, line 11, figures 2-5	1,2,4-13
X	Patent Abstracts of Japan, M-319, page 99 JP 59-74397 A (MATSUSHITA DENKI SANGYO K.K.) 26 April 1984 Abstract and Figure	1,2,4-13
X	Patent Abstract of Japan, M-575, page 81 JP 61-247899 A (NIPPON DENSO CO.LTD) 05 November 1986 Abstract and Figure	1,2, 4-13

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08 July 1999	14 JUL 1999

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